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Analysis on the Influence of Coal Strength to Risk of Outburst

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Abstract

The lower the coal strength is, the bigger the width of stress released zone is in front of the tunneling face. Enhancement of the stress released zone width may increase the resistance of outburst and reduce the outburst hazard; in fact, most outbursts take place in the soft seam. At first, the author analyzed the relation of coal mass strength and the width of stress released zone in front of the tunneling face; then, state that the stresses make change of the gas which is in the edge of the stress released zone; to analysis the relation between coal mass strength and the quantity of gas desorption per minute. According to the research result, the coal mass strength is lower, the width of stress distressed zone is bigger, and the quantity of gas desorption per minute is bigger; but, the latter is more dominant than the earlier ones. Finally, by making use of the research result, explained the gas abnormal phenomenon that is a sign of outburst premonition, and analyzed the mechanism of outburst prevention in coal seam infusion.

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Keywords: outburst; stress released zone; coal mass strength; gas desorption

1. Introduction

The outburst of coal and gas is comprehensive effect of ground stress, the pressure of gas, and the physical mechanics of coal [1-5]. The coal mass strength is a kind of the physical mechanics of coal. It has a close relation with the outburst of coal and gas. Therefore, In many country, coal mass strength is a one of prediction index [6]. Low coal mass strength is quite easy to break, the width of stress released zone is quite large in the front of coal face, the width of stress released zone is larger, risk of coal and gas

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outburst is smaller [7]. A large number of research experiments show that the coal mass strength is lower, the risk of coal and gas outburst is larger [8]. The conclusions are contradictory, so, the author analyses the relationship between the coal mass stress and the outburst of coal and gas.

2. Overview

In general, in front of coal face, the coal seam may be divided into stress released zone, stress concentration zone and original stress zone according to the stress distribution, and it is shown in figure 1.

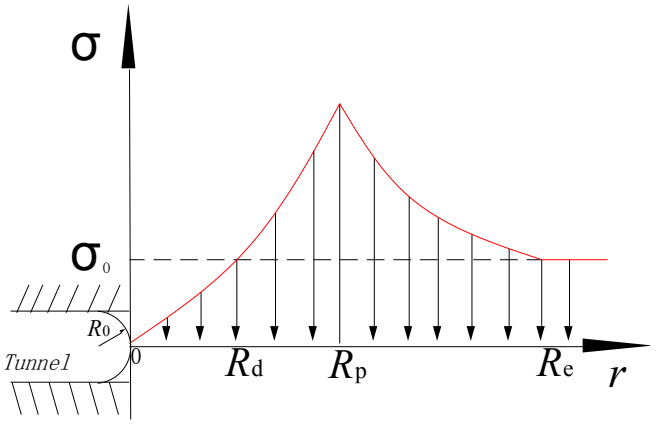

Fig 1-Stress distribution's graph in front of the tunneling face

In figure 1, r is the distance to tunneling face, σ is the ground stress, and σ_0 is the original stress. 0-R_d is the stress released zone, and the stress in this zone is lower than rock stress, and R_d is the width of the stress distressed zone. R_d- R_e is the stress concentration zone, and the stress in this zone is greater than original stress; it may be divided into plastic deformation zone (R_d- R_p) and elastic deformation zone (R_p-R_e). R_e-∞ is the original stress zone, and the stress in this zone is equal to original stress.

In the zone of 0−R_p, the stress can be expressed by the formula 1[8].

$$\sigma = \frac{0.1 + K\cot\phi}{1 - A_1}\left[\frac{1+\sin\phi}{1-\sin\phi}\left(\frac{r}{R_0}\right)^{\frac{4\sin\phi}{1-\sin\phi}} - 1\right] + \frac{0.1 - pA_1}{1 - A_1} \tag{1}$$

In formula 1:

K—cohesion, MPa;

ϕ—internal friction angle, rad;

A_1—porosity;

R_0—radius of tunneling, m;

p—gas pressure, MPa.

In formula 1, if r=R_d, σ=σ_0. Formula 2 is the transform of formula 1.

$$R_d = R_0\left(\left(\frac{\sigma_0 - \sigma_0 A_1 - 0.1 + pA_1}{0.1 + K\cot\phi} + 1\right)\frac{1-\sin\phi}{1+\sin\phi}\right)^{\frac{1-\sin\phi}{4\sin\phi}} \tag{2}$$

According to formula 2, There are two related factors with coal mass stress, they are K and ϕ. They have complex relations with R_d, especially ϕ. It is very difficult to discern it directly. Firstly, some parameters are presented, and it is shown as table Ⅰ; the sketch map about the relation of ϕ and R_d was drawn by making use of computer, and it is shown as figure 2.

Table 1 Some parameters of coal

Parameters	R_0 (m)	σ_0 (MPa)	A_1	P (MPa)	K (MPa)
Value	2	20	0.1	1	1

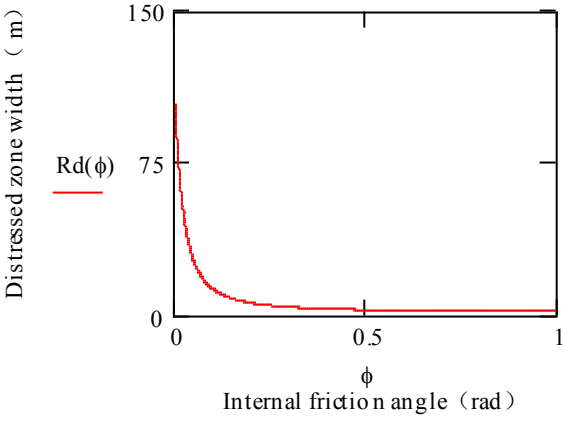

Fig 2-Sketch map about the relation of ϕ and Rd

In the same way, we may draw the sketch map about the relation of K and R_d, and it is shown as figure 3.

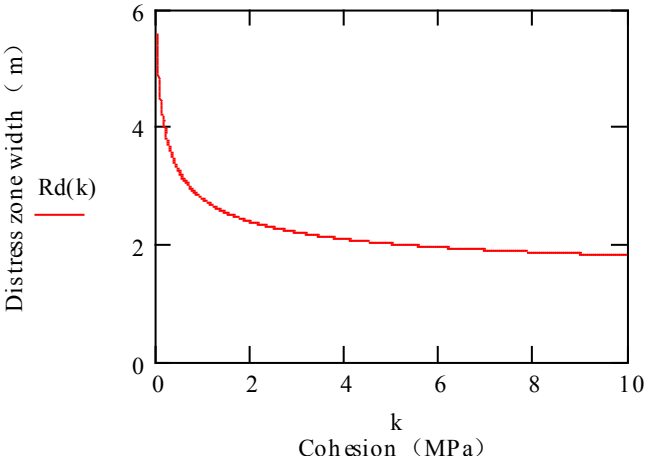

Fig 3-Sketch map about the relation of K and Rd

According to figure 2 and figure 3, in front of tunneling face, when cohesion and internal friction angle increase, the width of stress released zone decreases sharply. Therefore, the coal mass strength is lower, and the width of coal mass strength is larger.

3 The relationship between the quantity of gas desorption per minute and the risk of outburst

According to the experiment of the geomechanics and gas dynamics, validates that outburst takes place on the boundary of stress released zone frequently. Here, coal is fractured by stress in a elastic state, and new fractures appear in coal; the adsorption capacity of coal to gas greatly reduces during from elastic state to quasi-creep state, it brings that gas is adsorbed sharply, a large amount of gas from adsorption state to free state, and gas pressure is almost more than double, cause that the static and dynamic gas pressure is increased.

In unit time, the faster gas desorption, the more gas change from adsorption state to free state, so gas pressure is greater in the boundary of stress released zone, and the risk of outburst is greater.

Nowadays, because the relationship between the quantity of gas desorption per minute and the risk of outburst is closely, it is an index of outburst prediction in many countries. These indexes include ΔP which is gas releasing initial quantity of Soviet Union, West Germany $\Delta P_{0\text{-}60}$ and K_t , PolandΔP_{t2}, Australia V and index L_2 , the UK gas indices R , China's Δh_2 and K_1 , in addition ,France , Czechoslovakia and Japan and other countries have also made a number of outburst prediction indices about the quantity of gas desorption [6].

4 The relationship between coal mass strength and the quantity of gas desorption per minute

There are many indices which can described the quantity of gas desorption per minute, take h_2 as example, to analysis the relationship between coal mass strength and the quantity of gas desorption per minute. There are index of coal drilling cuttings, h_2 is solid particle size(1~3mm),weight(10g), fixed exposure time(3min), the difference of water height， and its signification is the quantity of gas desorption from the third minute to the fifth minute when the granularity is from 1 millimeter to 3 millimeters, and the weight is 10 grammes. Basically speaking, this is the quantity of the gas desorption per minute.

The Δh_2 was invented by Fushun branch of China coal mining research Institute and Beipiao coal mining administration together, there are a lot of data about theΔh_2 which is shown as figure 4.

In figure 4, the abscissa denotes coal consistence coefficient, and the ordinate denotes the desorption index. Δh_2 and there are six curves, they describe the relationship between coal consistence coefficient and the desorption index under different gas pressure. According to the measured data show that there are close relationship between desorption index and coal mass strength, In the same pressure, desorption indicesΔh_2 reduce with the coal mass stress increasing. Therefore, the lower of the coal mass strength, the faster gas desorption.

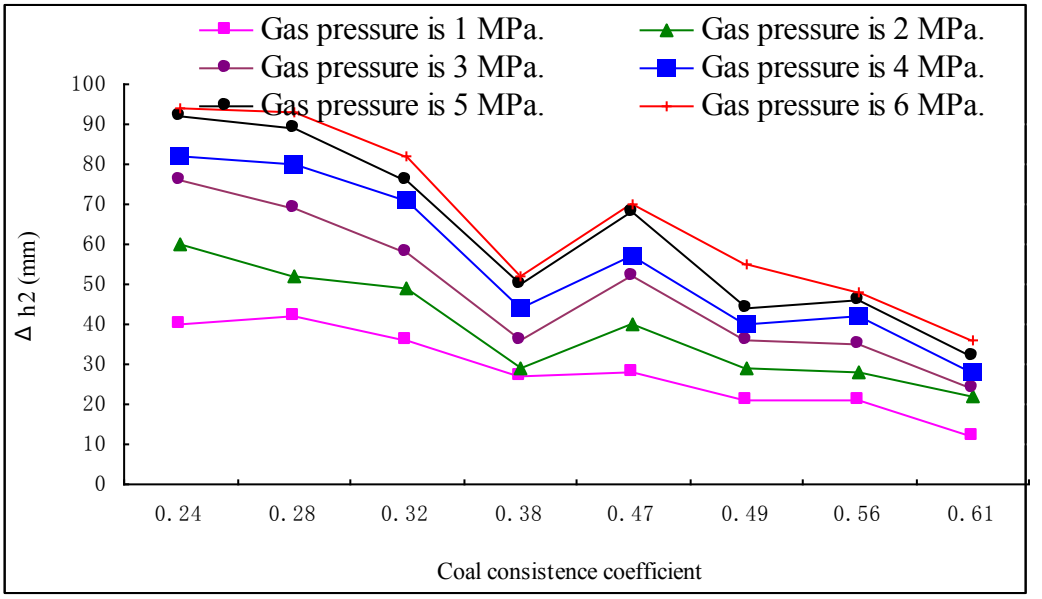

Fig 4-Sketch map about the relationship betweenΔ h2 and coal consistence coefficient

5 Influence of coal mass strength to the risk of outburst

The practice shows that if there is a certain width of the stress released zone in front of mining coal face [2]., it never happens dynamic phenomena, so the stress released zone has hindering effect to the outburst. With the coal mass strength reducing and the width of stress released zone increasing, the resistance of outburst increases, the risk of outburst should be reduced. However, in the edge of stress released zone, the lower coal mass strength is, the bigger gas desorpion quantity per minute is, so the risk of outburst is greater. Therefore the resistance and power of outburst are increasing when the coal mass strength is lower. In practice, the outburst mostly occurs in the soft coal seam, which indicates the changes of the quantity of gas desorption per minute have great impacts to the risk of outburst.

6 Application in practice

On the boundary of stress released zone, the coal is fractured by stress, and the gas is adsorbed sharply increasing, and gas pressure rises by a large amount constantly, which can brought the speed of gas emission increased and the density of gas is higher at the working face. Therefore, the working face gas density abnormity that is recognized a sign of outburst.

Coal seam water infusion is a common measure to prevent and control outburst. In the traditional opinion, the water is injected into the fracture and hole, and it may closing the passage of gas flowing; therefore, gas desorption quantity per minute decreased, which reduced risk of outburst after infusion in seam.

Laboratory tests showed that coal strength is lower after infusion in seam [7], which causes the width of stress released zone is bigger. Therefore, the mechanism of preventing outburst about infusion in coal seam are in two aspects: first, the coal strength is lower, and the width of stress released zone is bigger, and the resistance of outburst increases; second, gas desorption quantity per minute falls because the water have sealing effect on the gas.

7 Conclusions

1) The research transformed the stress expression in the rupture zone in front of tunneling face and analysed the relationship between coal mass strength and stress released zone.

The result indicated that the width of stress released zone essentially exponentially decreased with the coal mass strength increasing.

2) It analyzed the relationship between coal mass strength and the quantity of gas desorption per minute. The result indicated that the lower coal strength is, the bigger the quantity of gas desorption per minute is.

3) The width of stress released zone and the quantity of gas desorption per minute increased with the coal strength decreased. The changes of the quantity of gas desorption per minute have great impacts to the risk of outburst.

4) Before outburst, the density of gas is abnormal because most of gas is desorbed. After coal seam water infusion, the width stress released zone is another reason for the reduced risk of outburst.

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